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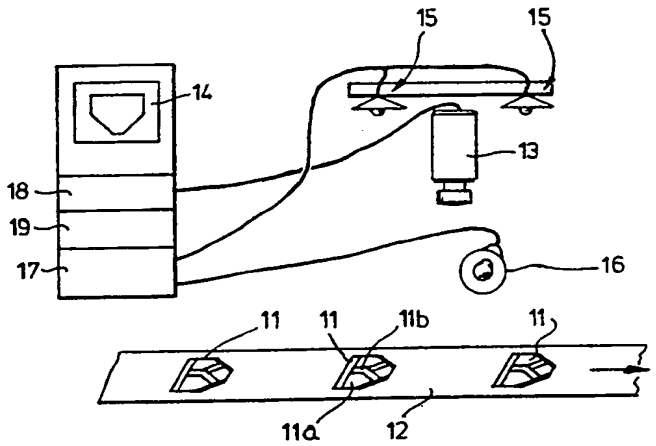
(54) Title: INSPECTING GARMENTS



(57) Abstract

There is disclosed a method and apparatus for automatically inspecting garments, which have panels separated by seams, by forming an image from the garment, identifying the seams on the image, and inspecting the panel areas individually.

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INSPECTING GARMENTS

This invention relates to inspecting garments and particularly garments such as Y-front underwear comprising garment panels separated by seams.

Inspection of mass-produced garments such as socks and underwear is a particularly labour-intensive operation. The garments are inspected, currently, by eye for dimensional defects and to check that the correct size label is applied, for making-up defects - badly sewn or missing seams, for example, for labelling defects, colour variations and fabric defects such as holes, stains, printing defects, colour defects and others. The number of personnel engaged on such inspection quite often substantially exceeds the number engaged in production.

Automatic inspection, using machine vision, is clearly desirable. The difficulty is to develop a methodology by which images can be formed and inspected automatically, sufficiently rapidly to keep pace with production, with a high detection efficiency and a low rejection rate for fault-free garments, using equipment which is not prohibitively expensive.

The invention comprises a method for automatically inspecting garments which have panels separated by seams, comprising the steps of :-

forming an image from the garment,

identifying the seams on the image, and

inspecting the panel areas individually.

The invention is particularly applicable to garments in which the seams themselves have width, when the seams may also be inspected.

Seams which stand proud of the adjacent panels - more generally, seams which have a z-coordinate with respect to the x,y coordinates of the garment surface - may be detected by shadows and highlights from oblique illumination.

The method of the invention may be adapted for inspecting Y-front underwear, which comprises panels edged with wide, raised seam and waistband structures, when it may comprise the steps of :-

forming an image of the front of the garment laid flat,

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locating on the image the outline of the garment,

locating on the image the edges of the wide, raised seam and waistband structures, and

inspecting the panels and the wide, raised seam and waistband structures located on the image for faults.

The garment may be measured for sizing from the image of the front of the garment, and may be illuminated with front lighting to form this image, after which the garment is illuminated with oblique lighting to locate the edges of the wide, raised seam and waistband structures and images thereof are superimposed on the image formed by front lighting.

The invention also comprises apparatus for automatically inspecting garments which have panels separated by seams comprising :-

imaging means for forming an image of the garment,

seam identifying means for identifying the seams on the image formed by the imaging means, and

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panel inspection means for individually inspecting the panel areas on the said image.

The imaging means may comprise an area scan video camera aimed at a background against which the garment can be laid flat and front and oblique lighting for garments so laid against the background.

The seam identifying means may comprise image processing means identifying highlights and shadows on an obliquely illuminated image and superimposing images thereof on a front-lit image of the garment.

The panel inspection means may comprise image processing means adapted to identify a panel on the image and process the same to detect faults therein according to predetermined criteria and to activate alarm or garment rejection arrangements upon fault detection.

The panel inspection means may be arranged to process each of a plurality of panels of the image sequentially. Fault recording means may be adapted to record the occurrences of faults associated with each of a plurality of panels on a batch inspection of similar garments. The apparatus may then also comprise heuristic control means arranging the said plurality of

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panels in a sequence for inspection according to the incidence of faults for each panel recorded as the batch inspection processes.

One embodiment of apparatus and a method for automatically inspecting garments according to the invention will now be described with reference to the accompanying drawings, in which :-

Figure 1 is a general view of the apparatus;

Figure 2 is a first image produced by the apparatus of Figure 1;

Figure 3 illustrates a processing step in assessing the dimensions of a garment from the first image;

Figure 4 is a second image produced by the apparatus;

Figure 5 illustrates a processing step in determining the positions of seams in the garment from the second image;

Figure 6 illustrates the step of superimposing seams located from the second image on the first image;

and Figure 7 illustrates a step in the fault detection operation.

The drawings illustrate automatic garment inspection apparatus engaged in the inspection of Y-front underwear 11 presented laid flat on a conveyor 12 passing beneath an area scan video camera 13 which images each garment in turn for processing in image processing apparatus 14.

Y-front underwear poses special problems for automatic, machine-vision inspection, inasmuch as it comprises panels 11a with intervening seams 11b. Treating the garment as a single panel would require the signals produced by the seams to be somehow ignored. Matching the image to a standard template does not take account of the fact that textile processes do not result in uniformly sized or configured garments.

The drawings illustrate a method in which the seams 11b are identified and the panel areas 11a inspected individually.

In Y-front underwear, the seams 14b themselves have width, and the method also allows the seams 11b to be inspected.

If the seams 11b could be relied upon to have a different colour or a different texture from the panels 11a, such difference could be used to identify the seams. However, generally speaking, the seams are identical with or very similar in appearance to the panels. Instead, in the preferred method of the invention, use is made of the fact that Y-front garment seams stand proud of the adjoining panels, that is to say they have a z-coordinate with respect to the x,y-coordinates of the garment surface.

It will be understood that the garments 14 have a front and a back and that both may require to be inspected. This is not necessarily the case - pre-inspection of fabric may reduce the incidence of fabric faults to negligible proportions, and thus the only faults which require to be detected are making-up faults, which may be found to occur almost entirely on the complicated front and hardly ever on the much simplar back of the garment. If both sides have to be inspected, however, the procedure will be repeated, mutatis mutando, with the garments, turned over. The present description will be with regard to inspection of the front. However, with some designs of Y-front underwear, laying the garment face up exposes the leg-opening seam all the way round, and then inspecting the reverse side may be unnecessary.

An image is first formed of the garment 11 using the front lighting set-up 15. This image - which might be averaged over two or more frames for noise-reduction purposes - is stored in a frame store of the apparatus 14 and segmented using an appropriate grey-scale threshold so that the image is uniformly dark against a bright background as seen in Figure 2 - or the other way round, of course, whichever is desired.

The outline of this image is then determined using a robot edge-follower program in which a notional robot group of pixels is scanned across the image until dark pixels are encountered and the group is then moved and rotated so as to maintain both light and dark pixels in its composition thus tracing out the edge of the image. The position of each step is stored so that at the end of the edge-tracing operation there is a collection of pixels of the image (x_i, y_i) that define the edge.

The centroid (X,Y) of the image - Figure 3 - is determined as

$$X = {}^{1}/_{N} \sum_{1-N} x_i, \quad Y = {}^{1}/_{N} \sum_{1-N} y_i$$

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where N is the number of points on the periphery, which is a reasonable approximation from a simple and rapid calculation.

The distance from the centroid (X,Y) of each edge pixel (x_i, y_i) is calculated as

$$D_i = \sqrt{[(X - x_i)^2 + (Y - y_i)^2]}$$

The image is then divided from the centroid into six areas a, b, c, d, e, f, each containing a single corner A, B, C, D, E, F, which is the point in the area furthest from the centroid. Each corner A, B, C, D, E, F is found by finding the highest D_i encountered in the course of stepping around all the edge points of the area.

Once the coordinates (x_A, y_A), (x_B, y_B), (x_C, y_C), (x_D, y_D), (x_E, y_E), (x_F, y_F) of the corners A, B, C, D, E, F have been found, the following dimensions are calculated :-

Side leg including waistband

$$A\text{-}C = \sqrt{[(x_A - x_C)^2 + (y_A - y_C)^2]}$$

Leg opening

$$C\text{-}E = \sqrt{[(x_C - x_E)^2 + (y_C - y_E)^2]}$$

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Crotch width

$$E\text{-}F = \sqrt{[(x_E - x_F)^2 + (Y_E - Y_F)^2]}$$

Waist

$$B\text{-}A = \sqrt{[(x_B - x_A)^2 + (Y_B - Y_A)^2]}$$

These dimensions are used to check that a garment of a given size is within tolerances or to separate garments of different sizes and to check that all measurements are within tolerances for the size so determined.

The conveyor 12 is conveniently stopped for the imaging so that once the first image referred to above has been captured using the front light arrangement 15, and the image sent for processing as described, the front illumination can be switched off and the oblique illumination 16 switched on, for a second, oblique-lit image to be formed. Since the seams 11b are raised this oblique lighting will highlight the edge of any seam nearest the light source and cast a shadow from the other edge. The position of the light source will be chosen with regard to the way the garments 11 are so presented on the conveyor 12 as to ensure that there is always a highlight and a shadow for each seam. A second image is now captured under this oblique illumination which contains information about the structure of the

garment within its periphery - the raised, wide seam and waistband structure. Figure 4 shows such a second image, with highlights 41 and shadows 42 indicating the edges of the seams 11b and the waistband.

The highlights 41 and shadows 42 are processed separately. The image (or rather a copy of it), to process the shadows, is grey-scale segmented using an appropriate threshold to leave just shadows information. Since the shadows will not necessarily be sharp and since there may be spurious shadows from other parts of the garment, the image is further processed appropriately to sharpen up the shadows and eliminate spurious information. One way to do this is to isolate features, starting e.g with vertical features, of which, in Y-front underwear there should be only one, namely the shadow of one edge of the centre vertical seam. A straight line is fitted to this feature by defining a box including the uppermost, lowermost and extreme lateral points and testing straight lines passing through the box, generated automatically by a series of equations to select the one that passes through the most data points - using a suitable segmentation threshold level to separate the shadow information will result in that information being a set of isolated data points rather than an extended area, as shown in Figure 5, which shows a trial line 51 being fitted to a set of shadow points 52 on an inclined seam edge.

This process is repeated for all the other shadow sections until an image can be assembled of the sharpened-up shadow region. The same is then done for the highlights, so as to produce a diagram like Figure 6 showing a representation on the image first captured.

The image is now divided up into sections S_1, S_2 etc bounded either by an edges, shadows and highlights. Each section S_1, S_2 etc, whether it be of a panel 11a or a wide seam 11b, is then isolated and subjected to fault detection processing by image segmentation using an appropriate threshold level, and filtering or any other appropriate technique to check for extended areas of differentation from the threshold background which indicate fabric and/or making-up faults. Figure 7 shows the waistband area S_1 so separated for the fault detection operation, the remainder of the sections S_2-S_7 being examined in turn.

Of course, if a fault is detected, further inspection might be regarded as futile, and the inspection process might usefully be terminated with the apparatus activating an alarm or rejection mechanism 19 (Figure 1).

It may be found that one region has significantly more faults than others, and it will advantageously be

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arranged that the apparatus stores statistics from which this can be determined and which can be used to determine the ranking order for the panels 11a and 11b of the garment 11 for fault occurrence. Then the section with the highest number of faults can be selected to be examined first into the fault detection stage, the arrangement operating thus heuristically. Of course, the thus collected statistics may also be used to determine which area of manufacture must be tackled first from the point of view of fault elimination.

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CLAIMS

1. A method for automatically inspecting garments, which have panels separated by seams, comprising the steps of :-

forming an image from the garment,

identifying the seams on the image, and

inspecting the panel areas individually.

2. A method according to claim 1 for garments, in which the seams themselves have width and the seams are also inspected.

3. A method according to claim 1 or claim 2, in which seams which have a z-coordinate with respect to the x,y coordinates of the garment surface are detected by shadows and highlights from oblique illumination.

4. A method according to any one of claims 1 to 3, for inspecting Y-front underwear, which comprises panels edged with wide, raised seam and waistband structures, comprising the steps of :-

forming an image of the front of the garment laid flat,

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locating on the image the outline of the garment,

locating on the image the edges of the wide, raised seam and waistband structures, and

inspecting the panels and the wide, raised seam and waistband structures located on the image for faults.

5. A method according to claim 4, in which the garment is measured for sizing from the image of the front of the garment.

6. A method according to claim 4 or claim 5, in which the garment is illuminated with front lighting to form the image.

7. A method according to claim 6, in which the garment is illuminated with oblique lighting to locate the edges of the wide, raised seam and waistband structures and images thereof are superimposed on the image formed by front lighting.

8. Apparatus for automatically inspecting garments which have panels separated by seams comprising :-

imaging means for forming an inage of the garment,

seam identifying means for identifying the seams on the image formed by the imaging means, and

panel inspection means for individually inspecting the panel areas on the said image.

9. Apparatus according to claim 8, in which the imaging means comprise an area scan video camera aimed at a background against which the garment can be laid flat and front and oblique lighting for a garment so laid against the background.

10. Apparatus according to claim 9, in which the seam identifying means comprise image processing means identifying highlights and shadows on an obliquely illuminated image and superimposing images thereof on a front-lit image of the garment.

11. Apparatus according to any one of claims 8 to 10, in which the panel inspection means comprise image processing means adapted to identify a panel on the image and the same to detect faults therein according to predetermined criteria and to activate alarm or garment rejection arrangements upon fault detection.

12. Apparatus according to any one of claims 8 to 11, in which the panel inspection means are arranged to

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process each of a plurality of panels of the image sequentially.

13. Apparatus according to claim 12, comprising fault recording means adapted to record the occurrences of the faults associated with each of a plurality of panels on a batch inspection of similar garments.

14. Apparatus according to claim 13, comprising heuristic control means arranging the said plurality of panels in a sequence for inspection according to the incidence of faults for each panel recorded as the batch inspection progresses.

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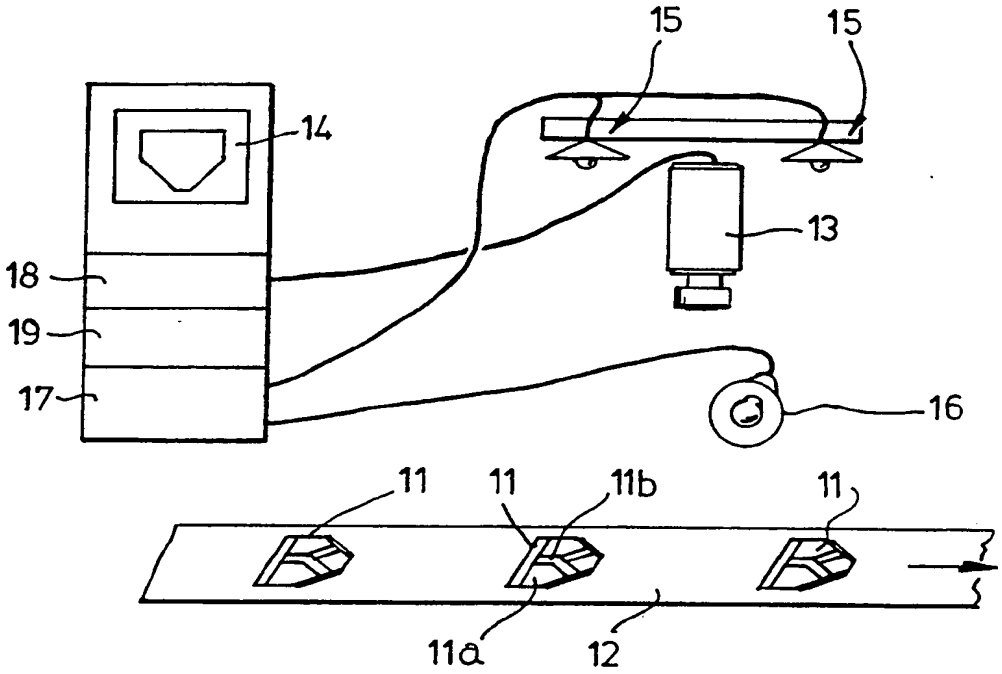


FIG.1

FIG.2

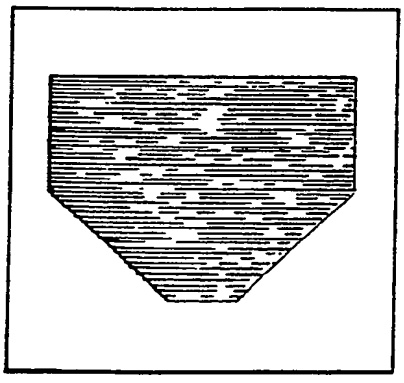
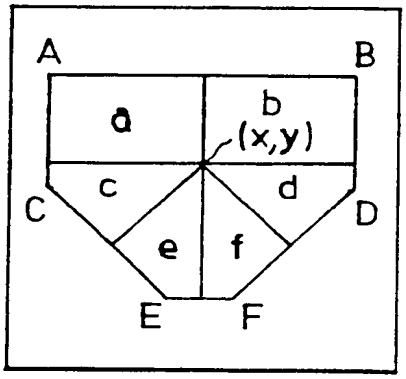


FIG.3



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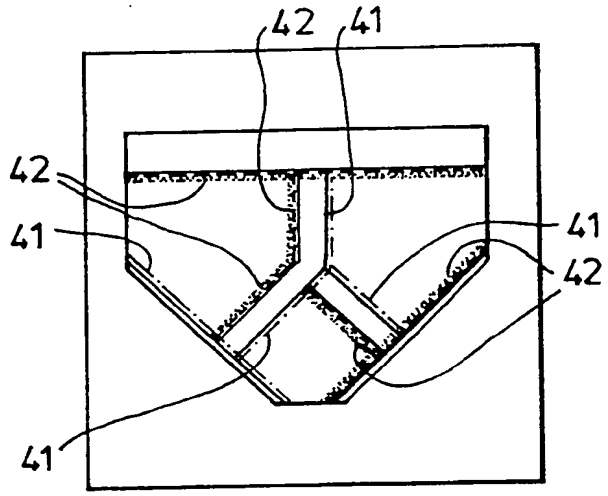

FIG.4

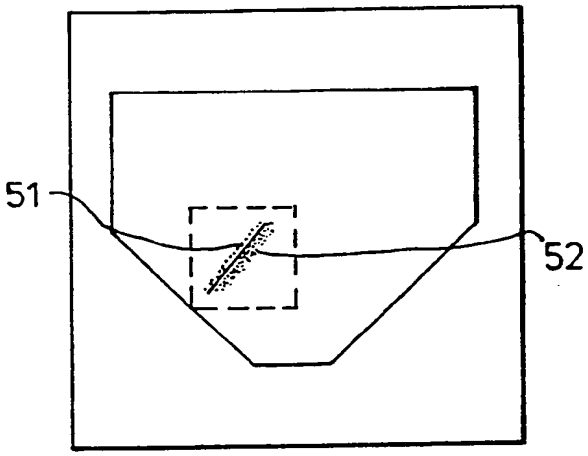

FIG.5

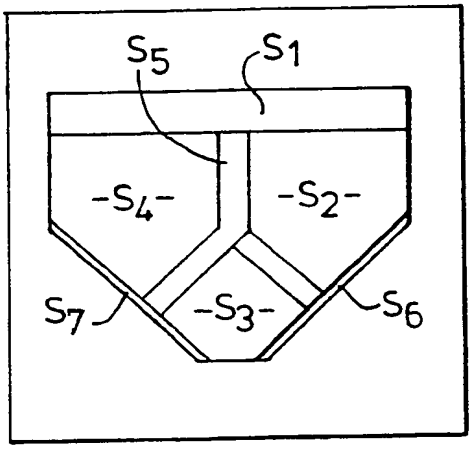

FIG.6

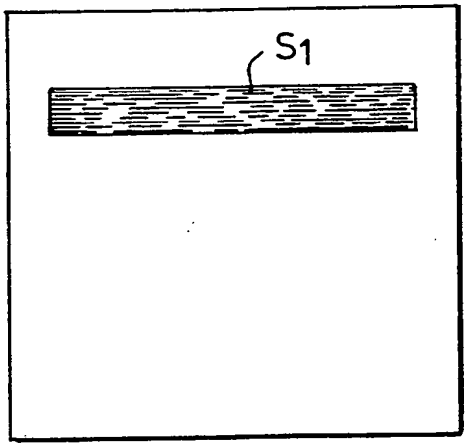

FIG.7

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INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/01414

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 01 N 21/84; 33/36

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
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Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	GB, A, 2186365 (LEICESTER POLYTECHNIC) 12 August 1987, see abstract	1-14
A	EP, A1, 0363177 (GEC ELECTRICAL PROJECTS LIMITED) 11 April 1990, see abstract	1-14
A	DE, A1, 3640851 (TECHNISCHE HOCHSCHULE KARL-MARX-STADT) 19 June 1987, see abstract	1-14

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1st November 1991	27 NOV 1991
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	KISS T. TAZELAAR

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
GB-A- 2186365	12/08/87	DE-A-	3426056	24/01/85
		GB-A-B-	2144219	27/02/85
		GB-A-B-	2192276	06/01/88
		US-A-	4744035	10/05/88
EP-A1- 0363177	11/04/90	GB-A-	2225652	06/06/90
DE-A1- 3640851	19/06/87	NONE		

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